AN ENVIRO-LEGAL ANALYSIS OF BIO-MEDICAL WASTE MANAGEMENT: EVALUATION OF EXISTING LEGISLATION AND POLICY WITH SPECIAL REFERENCE TO HOSPITALS IN DEHRADUN CITY

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CANDIDATE'S DECLARATION

I, **Navmi Joshi**, hereby announce that the synopsis titled, **"An Enviro-Legal Analysis of Bio-medical waste Management: Evaluation of Existing Legislation and Policy with Special Reference to Hospitals in Dehradun City"** is being submitted in the partial fulfilment of the requirement for the award of the degree of Doctor of Philosophy in **Law** under ICFAI Law School, The ICFAI University, Dehradun during the academic year 2025-26.

The work is projected to be conducted under the supervision of **Dr. Suneel Kumar & Dr. Vivek Kumar**. It is also announced that the synopsis is within the plagiarism limit and a copy of the same is attached as per the University norms.

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It is further declared that the synopsis is within the plagiarism limit and copy of the same is attached as per the University norms.

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ABSTRACT

Bio-medical waste management remains a critical environmental and public health concern in rapidly urbanizing cities like Dehradun, Uttarakhand. Irrespective of having Biomedical Waste Management Rules 2016" and other robust frameworks, there are still challenges related to effective compliance and implementation. This study is a modest attempt to determine the relationship between environmental sustainability, legal frameworks, effects on public health, and "biomedical waste management (BMW)" approaches in Dehradun. Key findings of the study reveal major infrastructural challenges, issues related to regulatory implementation, and biohazard handling contributing to degradation of environment and health risks for people.

Legal involvements have been important to promote application. However, there are systematic gaps because of limited potential in smaller medical units and poor coordination across government agencies. The study interpolates urgent demand for policy reforms, improved tracking, technological innovation, and programs related to capacity-building to promote sustainable waste control. This study suggests introduction of digital tracking, expansion of treatment facilities, promoting public-private partnerships (PPP), and heavy fines against perpetrators. This study provides data-driven, in-depth assessment of managing biomedical waste in context of Dehradun for healthcare stakeholders, policymakers, and environmental bodies to improve public health, compliance, and sustainability.

Keywords: *Bio-medical waste Management, Dehradun, Environmental Governance, Legal Framework, Judicial Intervention, Regulatory Compliance.*

1. Introduction

"***Any waste, which is generated during the diagnosis, treatment, or immunization of human beings or animals or research activities pertaining thereto or in the production or testing of biological or in health camps, including the categories mentioned in schedule I attach to bio-medical waste rules 2016*** -World health organization (WHO)".

It is possible to classify 'bio-medical waste' as infectious waste. ''biological waste'' is another kind of trash that seems to have its origins in the medical or obviously laboratory-generated waste industries. Extraneous substances, such as prohibited organisms or biomolecules, are another kind of trash. 'bio-medical waste' includes the disposal of sharps regardless of whether or not they are infectious[1]. The ability to do injury is increased when blood is properly tainted and disposed of. 'bio-medical waste' is one kind of bio-waste. Solid or liquid forms are both acceptable for 'bio-medical waste'. Bandages, dressings, gloves, undesired microbiological cultures and stocks, sharp items, blood, other bodily fluids, recognizable human or animal parts, and so on are all examples of infectious waste. Sharps include anything that may penetrate the flesh, such as needles, scalpels, lancets, and so on. The processes of biology and medicine produce trash known as 'bio-medical waste'. Home health organizations, funeral homes, veterinary clinics, dentistry offices, nursing homes, and hospitals are some of the most prominent biological manufacturers in the healthcare industry[2]. If the material in question exhibits these characteristics, it may be clinical or ''medical waste''. It is important to separate 'bio-medical waste' from other forms of hazardous waste, such as chemical, radioactive, and industrial waste", as well as from regular trash.

Several countries are now facing a major problem with 'biological waste' due to the fast expansion of healthcare institutions. Recently, hospitals, ecologists, and nursing home administrators have been grappling with the issue of 'bio-medical waste' disposal. There are a lot of variables affecting quantity of 'biological waste' that healthcare facilities create[3]. Access

[1]"Agamuthu, P., &Barasarathi, J. (2021). Clinical waste management under COVID-19 scenario in Malaysia. *Waste Management & Research, 39*, 18-26. https://doi.org/10.1177/0734242X20959701"

[2]"Akter, F., Amin, M. R., Osman, K. T., Anwar, M. N., Karim, M. M., & Hossain, M. A. (2012). Ciprofloxacin-resistant *Escherichia coli* in hospital wastewater of Bangladesh and prediction of its mechanism of resistance. *World Journal of Microbiology and Biotechnology, 28*, 827-834. https://doi.org/10.1007/S11274-011-0875-3"

[3] "Dumka, A., &Khanduri, P. (2018). KAP study on bio-medical waste management among nursing professionals in Haldwani (Nainital). International Journal of Advanced Scientific Research and Management, 3(8), 141-148."

to infrastructure and resources, percentage of reusable items, unit specialization, healthcare facility type, occupancy rate, and ‘waste management’ procedures are among these variables.

Right now, there is no more pressing humanitarian concern on a global scale than the proper disposal of ‘biological waste’. Worldwide, people are quite worried about the possibility of ‘bio-medical waste’ being mishandled “and posing a threat to both human and environmental health. It is” already common knowledge that the "hospital waste" produced by healthcare facilities has several negative effects on humans and the environment[4]. Everyone from the general population and medical professionals to nearby plants and animals are at risk from toxic hospital waste. Healthcare institutions' trash disposal problems have recently garnered a lot of attention.

But there are still a lot of obstacles to ‘waste management’ regulations being enforced. The transmission of infectious diseases including HIV, cholera, and hepatitis is facilitated by the heartless and careless management of ‘biological waste’ by healthcare institutions[5]. It endangers human and environmental health and stymies sustainability efforts because to the toxic substances it emits into our water, air, and soil. Our ecosystems, along with the plants and animals therein, were endangered due to this pollution. The physical setting in which a person lives is only one component of their environment; other components include their biological, social, and cultural milieu. Ensuring that everyone has the right to survive cannot be achieved just via the preservation and improvement of the natural environment[6]. Both Article 25(2) of the UDHR and “Article 21 of the Indian Constitution[7] uphold the right to health” and wellness, which encompasses medical care, illness, and incapacity. The "Right to Life" of individuals is safeguarded by the appropriate management of ‘biological waste’. The quantity of healthcare facilities, both public and private, has grown substantially in the last few years. World leaders met at the 1972 Stockholm Conference to set standards for protecting and

[4] “Chand, S., Shastry, C. S., Hiremath, S., Joel, J. J., Krishnabhat, C. H., &Mateti, U. V. (2021). Updates on biomedical waste management during COVID-19: The Indian scenario. Clinical Epidemiology and Global Health. https://doi.org/10.1016/j.cegh.2021.100715”

[5] “Ansari, M., Ehrampoush, M. H., Farzadkia, M., & Ahmadi, E. (2019). Dynamic assessment of economic and environmental performance index and generation, composition, environmental and human health risks of hospital solid waste in developing countries: A state-of-the-art review. Environmental International, 132, 105073. https://doi.org/10.1016/j.envint.2019.105073”

[6] “Chisholm, J. M., Zamani, R., Negm, A. M., Said, N., Abdel daiem, M. M., Dibaj, M., &Akrami, M. (2021). Sustainable waste management of medical waste in African developing countries: A narrative review. Waste Management & Research, 39(9), 1149-1163.”

[7]“Chowbe, Vijaykumar Shrikrushna, Legal Analysis of Rights Against the Protection of ‘Bio-Medical Waste’ and Judicial Reflections in India (March 1, 2011). Available at SSRN: https://ssrn.com/abstract=1773390 or http://dx.doi.org/10.2139/ssrn.1773390”

improving Earth's ecosystems for future generations[8]. Efforts to tackle environmental governance started with this. In their 1996 decision B.L. Wadhera v. Union of India[9], which dealt with MSW, the Indian Supreme Court tackled the problem "of 'bio-medical waste' management. In healthcare facilities", this new issue had emerged. Emerging as a major player, India has made significant efforts to curb its 'bio-medical waste'. "The Bio-'medical waste' (Management and Handling) Rules[10], 1998 were drafted by the Ministry of Environment and Forests (MoEF) of the Government of India. This regulatory body exercised its authority under sections 3, 6, and 25 of the Environment (Protection) Act, 1986"[11]. "The National Environment Policy of 2006" lays out successful public-private cooperation strategies for biohazard and hazardous waste disposal. In addition, the "National Green Tribunal Act, 2010"[12] established a green tribunal as an alternative institutional vehicle to facilitate the prompt and effective settlement of disputes involving 'bio-medical waste' restrictions, environmental rights, and personal and property losses. To that end, effective BMWM is required by law and by morality. In order to accomplish the recycling and waste reduction goals set "by the United Nations Conference on Sustainable Development", this article presents a thorough examination of the legal and judicial components of 'biological waste' management.

Due to certain institutions' negligent, inaccurate, and indiscriminate garbage disposal methods, many hospitals suffer from an absence of adequate 'biological waste' management enforcement. When there are no systems in place to separate 'medical waste' from regular rubbish, the result is a hazardous waste stream[13]. Errors in waste disposal processes result from improper sorting. Negligible 'bio-medical waste' management leads to environmental pollution, unpleasant odors, the spread of pests like worms, rats, and insects, and the potential

[8] "Datta, P., Mohi, G., &Chander, J. (2018). Biomedical waste management in India: Critical appraisal. Journal of laboratory physicians, 10(01), 006-014.

[9]Achak, M., Alaoui, S. B., Chhiti, Y., Ezzahrae, F., Alaoui, M., Barka, N., &Boumya, W. (2020). SARS-CoV-2 in hospital wastewater during outbreak of COVID-19: A review on detection, survival and disinfection technologies. Science of the Total Environment, 143192. https://doi.org/10.1016/j.scitotenv.2020.143192

[10] Amoah, I. D., Abunama, T., Awolusi, O. O., Pillay, L., Pillay, K., Kumari, S., &Bux, F. (2022). Effect of selected wastewater characteristics on estimation of SARS-CoV-2 viral load in wastewater. Environmental Research, 203, 111877. https://doi.org/10.1016/J.ENVRES.2021.111877

[11] Feedback Foundation. (n.d.). Integrated decentralized solid waste management model at Nathuwawala, Ward 100, Dehradun. Retrieved from https://www.feedbackfoundation.org

[12] Goli, V. S. N. S., Singh, D. N., & Baser, T. (2021). A critical review on thermal treatment technologies of combustible fractions from mechanical biological treatment plants. Journal of Environmental Chemical Engineering, 9(4), 105643."

[13]"Arub, S., Ahmad, S. R., Ashraf, S., Majid, Z., Rahat, S., &Paracha, R. I. (2020). Assessment of waste generation rate in teaching hospitals of metropolitan city of Pakistan. Civil Engineering Journal, 6. https://doi.org/10.28991/cej-2020-03091584

for diseases such as ‘typhoid’, ‘hepatitis’, ‘cholera’, and ‘AIDS’ as a result of needle sticks and other injuries caused by syringes and other instruments contaminated with human pathogens. It is critical to avoid coming into contact with perspiration, blood, and other body fluids, as well as injured organs, as they might spread infectious diseases. Pests such as flies, insects, rodents, cats, and dogs may proliferate in hospitals and transmit illnesses including plague and rabies[14]. Hospital rag pickers risk tetanus and HIV infections for both themselves and their patients. Transmission of infectious illnesses including hepatitis and HIV may occur when intravenous sets, glass bottles, disposable syringes, and needles are not properly cleaned before being reused. The most eco-friendly and secure ways of disposing of hospital waste should be the top priorities for health administrators. Managers in healthcare facilities are making an effort to stay abreast of developments in the field and actively seek out new, safe, and cost-effective ways of handling ‘biological waste’[15]. The foundation of healthcare quality assurance is reliable hospital ‘waste management’ systems.

In light of the increasing concerns over ‘bio-medical waste’ management, this research endeavours to offer an empirical analysis of the environmental and legal regulations governing hospital waste in Dehradun. The study's overarching goal is to highlight enforcement gaps, environmental risks, and healthcare institutions' challenges by analysing existing policies, ‘waste management’ plans, and regulatory compliance. The results will provide useful information for environmental authorities, hospitals, and legislators helping them create better “‘waste management’ systems. In order to protect public health and the environment”, this research underlines finally the pressing necessity of sustainable and legally acceptable ‘bio-medical waste’ disposal systems.

2. Research Problem

The combustion of ‘medical waste’ releases persistent organic pollutants (POPs) into the air, a growing threat to environmental and human health that is directly related to ‘‘bio-medical waste’ management’. The UN human rights office reports that ‘‘medical waste’’ has become a reason due to the healthcare industry's rapid expansion. In 2015, a global initiative was initiated “by the World Health Organization and the United Nations Children's Fund (UNICEF) to ensure that all healthcare facilities” are equipped with potable water, efficient sanitation and

[14]https://cpcb.nic.in/uploads/Projects/Bio-Medical-Waste/AR_BMWM_2022.pdf”
[15] “Joshi, A., & Joshi, N. (2020). Sanitation Park Nathuwawala, Dehradun: A study of solid waste management in Uttarakhand. Current World Environment, 15(1), 87–99.”

hygiene services, and a system to manage healthcare waste[16]. As an additional component of their Sustainable Development monitoring for appropriately managed water and sanitation, they are also working together to supervise a program that aims to ensure the safe handling of 'biological waste' and sanitation inside healthcare institutions. India ranks as the 6th-largest developing nation in the world and the second-most populated country overall. From 2001–2011, the average annual exponential growth rate was 1.64%. Nearly eighty-five percent of hospital trash is classified as "non-hazardous", while just five percent is considered very toxic, according to the report. Due to insufficient education and oversight, the disposal of all 'bio-medical waste' with MSW is a major problem in 'waste management'.[17] The International Clinical Epidemiology Network performed a statewide study and found that improper ultimate disposal and insufficient treatment of 'biological waste' at the source were major problems. Some 82% of primary care, "60% of secondary care, and 54% of tertiary care" institutions do not have reliable and efficient 'biomedical waste' management. Have a dozen Solid garbage production averaged over 150,000 tons daily in 2016–17, according data from the Ministry of Housing and Urban Affairs[18]. A study conducted by ASSOCHAM and Velocity estimates that the daily 'medical waste' creation in India is 550.9 tons now, and is likely to reach 775.5 tons by 2022.

In regions experiencing rapid urbanization and increasing healthcare infrastructure, the inadequate management of 'bio-medical waste' (BMW) significantly jeopardizes public health and environmental sustainability. The generation of 'bio-medical waste' has surged in the Dehradun due to the proliferation of hospitals, clinics, laboratories, and other healthcare facilities. Conversely, inadequate treatment facilities, inefficient waste disposal practices, and lenient regulatory enforcement have exacerbated the "risks associated with improper hospital 'waste management'". Despite the existence of the 'biological waste' Management Rules, 2016, there are significant deficiencies in compliance, segregation, transportation, and disposal of 'biological waste'[19]. Numerous medical institutions either fail to ensure safe disposal or lack adequate waste segregation methods, so harming soil, aquatic environments, and the

[16] Recykal. (2024). Transforming waste management in Uttarakhand: The Char Dham success story. Retrieved from https://recykal.com/blog/transforming-waste-management-in-uttarakhand-the-char-dham-success-story

[17] "Arslan, A., Veli, S., & Bingöl, D. (2014). Use of response surface methodology for pretreatment of hospital wastewater by O3/UV and O3/UV/H2O2 processes. Separation and Purification Technology, 132, 561-567. https://doi.org/10.1016/j.seppur.2014.05.036"

[18] https://srhu.edu.in/wp-content/uploads/2023/12/Policy%20for%20Bio-medical%20Waste%20Management.pdf

[19] https://cpcb.nic.in/uploads/Projects/Bio-Medical-Waste/AR_BMWM_2018.pdf

atmosphere. Additional exacerbating health and environmental risks are illicit disposal of infectious waste, improper incineration, and unregulated hazardous material recycling. The deficiency of information and training among municipal authorities, 'waste management', and medical practitioners about "the proper disposal of 'biological waste' is a significant impediment. Common 'bio-medical waste' Treatment Facilities (CBWTFs)" are inaccessible to several small healthcare facilities, particularly in rural and semi-urban areas, leading to hazardous disposal practices like as incineration, open dumping, or amalgamation with municipal waste.

In addition, limited organization, lack of resources, and technological gap in critical infrastructure drastically affect governance in adopting and tracking regulations. The assurance of compliance is further complicated with the lack of national-level system for waste management[20]. This study aims to determine environmental and legal "biomedical waste" regulation in context of policy problems, key issues, and potential solutions to improve bio-waste management and regulatory framework.

3. Literature Review

The effective management of "bio-medical waste (BMW) is an essential public health and environmental concern. The improper management and disposal of hospital waste have contributed to growing fears of contamination, disease spread, and environmental degradation. Various national and international research studies have examined the legal aspects, environmental consequences, and technological innovations in the management of 'bio-medical waste', underlining the necessity of rigorous regulation enforcement and eco-friendly disposal mechanisms.

For the purpose of this research the literature review has been conducted in two Phase, the first phase includes the Bibliometric analysis of the scientific database literature around the 'bio-medical waste' and regulation whereas the second phase include the systematic literature review from the Google Scholar and Shodhganga. To perform the Bibliometric analysis methodology suggested by Rowley and Sack. has been adopted. Researchers who have released bibliometric studies in a variety of fields have generally agreed with this method. which comprises the methodical process centred on the field of literature, beginning with the initial

[20] National Green Tribunal (NGT). (2016, July 20). Ensure proper disposal of bio-medical waste, NGT tells Uttarakhand hospitals. The Hindu. Retrieved from https://www.thehindu.com

data collection and continuing with the shortlisting of relevant research articles using criteria such as title, abstract, keywords, and filters to guarantee that only the relevant papers are considered. Lastly, the study's data was analysed using a bibliometric and mapping of networks program to uncover important conclusions. The detail process can be shown in the [Figure. 1] which depicts the adopted PRISMA for bibliometric study.

Step 1: finding the appropriate database to do a literature review

In order to begin with the bibliometric evaluation of the selected literature, the first step is to choose the appropriate databases to use, such as Scopus and WoS. Due to their comprehensive coverage of academic literature, including the field's "bio-medical waste" rules, both databases are significant academic resources. Advanced features are helpful sorting tools for sifting through research documents with specific keywords and names of authors and dates when the work was published. Besides, academics enjoy more visibility when they publish in journals indexed in Scopus and WoS, and thereby improve the potential impact of their work.

Step 2: Search Syntex

In a bibliometric analysis, identifying keywords is a fundamental aspect since it impacts the comprehensiveness of the search. The collated keyword list acts as the basis of the integrated search that seeks to capture all relevant research articles by the knowledge domain. Such the search for ‘research literature’ was made using a keyword string that consisted of ("‘bio-medical waste’" ‘OR’ "healthcare waste" ‘OR’ "‘medical waste’" ‘AND’ legal ‘OR’ law ‘OR’ rule ‘OR’ regulations) in order to ensure coverage of all related researches in this field. The time frame of the study was set from 2014 to 2024 and the search was conducted on January 20th 2025.

Database	Search Syntext
Scopus (https://www.scopus.com)	"‘bio-medical waste’" ‘OR’ "healthcare waste" ‘OR’ "‘medical waste’" ‘AND’ legal ‘OR’ law ‘OR’ rule ‘OR’ regulations
WoS (https://www.webofscience.com)	"‘bio-medical waste’" ‘OR’ "healthcare waste" ‘OR’ "‘medical waste’" ‘AND’ legal ‘OR’ law ‘OR’ rule OR regulations

Table 1: Search Syntext

Step 3: Summaries of the literature review

The search process began in the “Scopus” databases with the search string TITLE "‘bio-medical waste’" ‘OR’ "healthcare waste" ‘OR’ "‘medical waste’" ‘AND’ legal ‘OR’ law ‘OR’ rule ‘AND’ regulations, yielding 325 articles as shown in Fig.2. Similarly, the same query was conducted in the “Web of Science” database, resulting in 243 articles as shown in Fig 3. To focus on extracting significant articles containing "liability" and "artificial intelligence" solely in the title, the search queries for both databases were narrowed down to titles only.

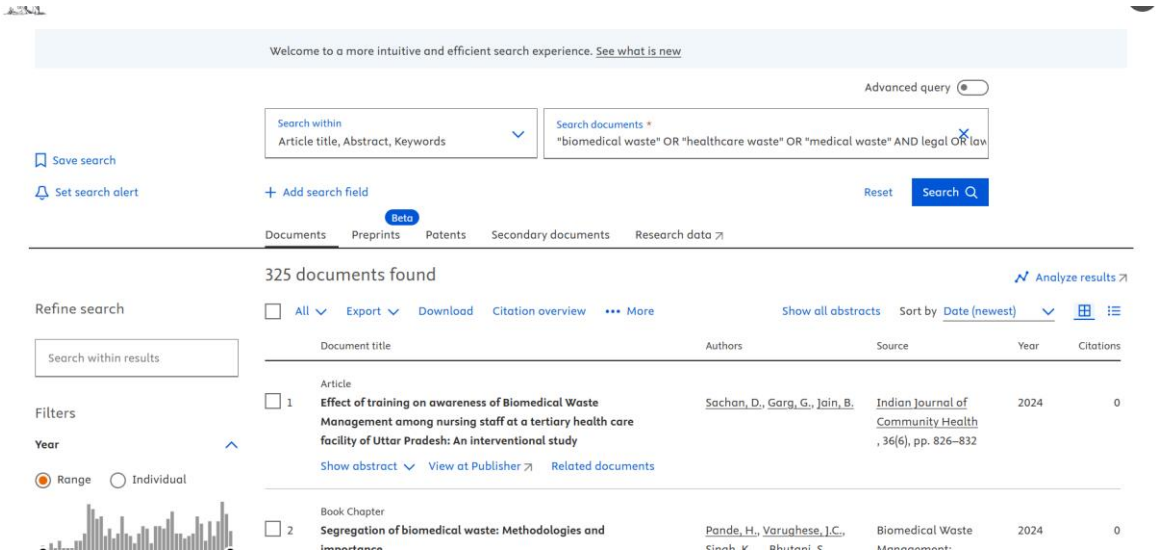

Fig.1: “Scopus” Search result

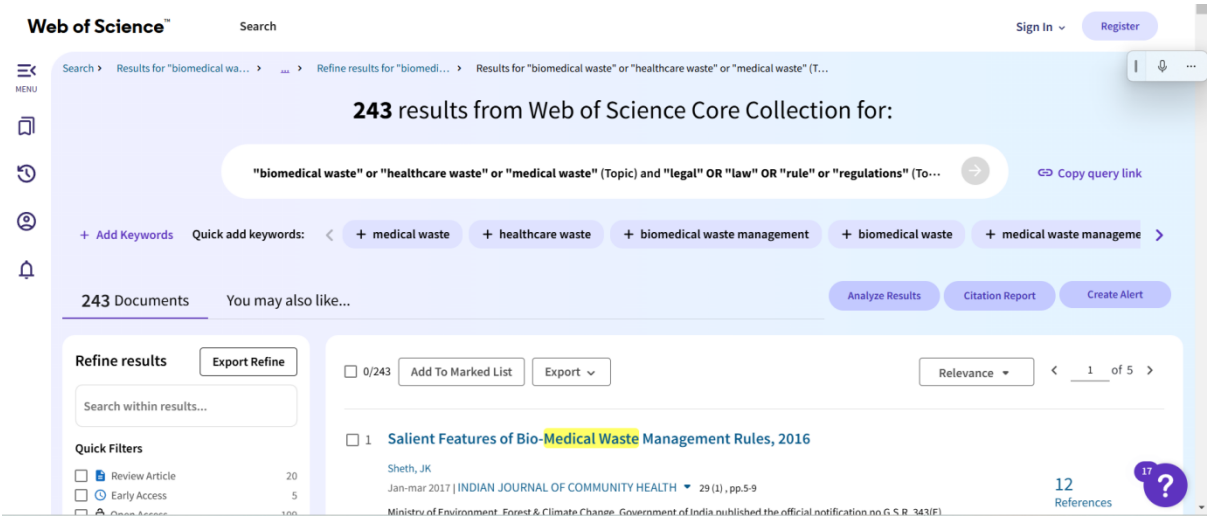

Fig.2: Web of science” result

Step 4: Application of filters

When researching, the data set is bound to get filtered multiple times to ensure a refined result. the first filter collected resource from 2014-2024. the filter which was English filter refined to article, conference paper and book chapter was applied during extraction. These filters resulted in collection of 89 papers from Scopus and 163 from WoS. Both databases were compared for overlap and found that there were 41 WoS papers already in Scopus. Thus, the final data set consisted of 211 papers from Scopus, which were cleaned from duplicates with R.

Step 5: bibliometric tool

To perform analysis on the data the R-studio bibliometric tool 'Biblioshiny' for meta-bibliometric analysis. The technology behind Biblioshiny is an open-source programming language and environment called R, which supports all the features of Biblioshiny. This method just originated from Aria and Cuccurullo [31] in their classical article that gave the reference of business. According to their paper, the process was composed by three main steps. Step 1 was related to data collection which was extracting, loading, transforming and cleaning the data. This crucial first step assured primacy in the data. The second step was to make a thorough data analysis through interpreting the outcomes with the description and citation analysis of writing by identifying tacit patterns within the literature body. This step which is the analysis part made graphs to give life to our data comprehension. These were in form of concept.

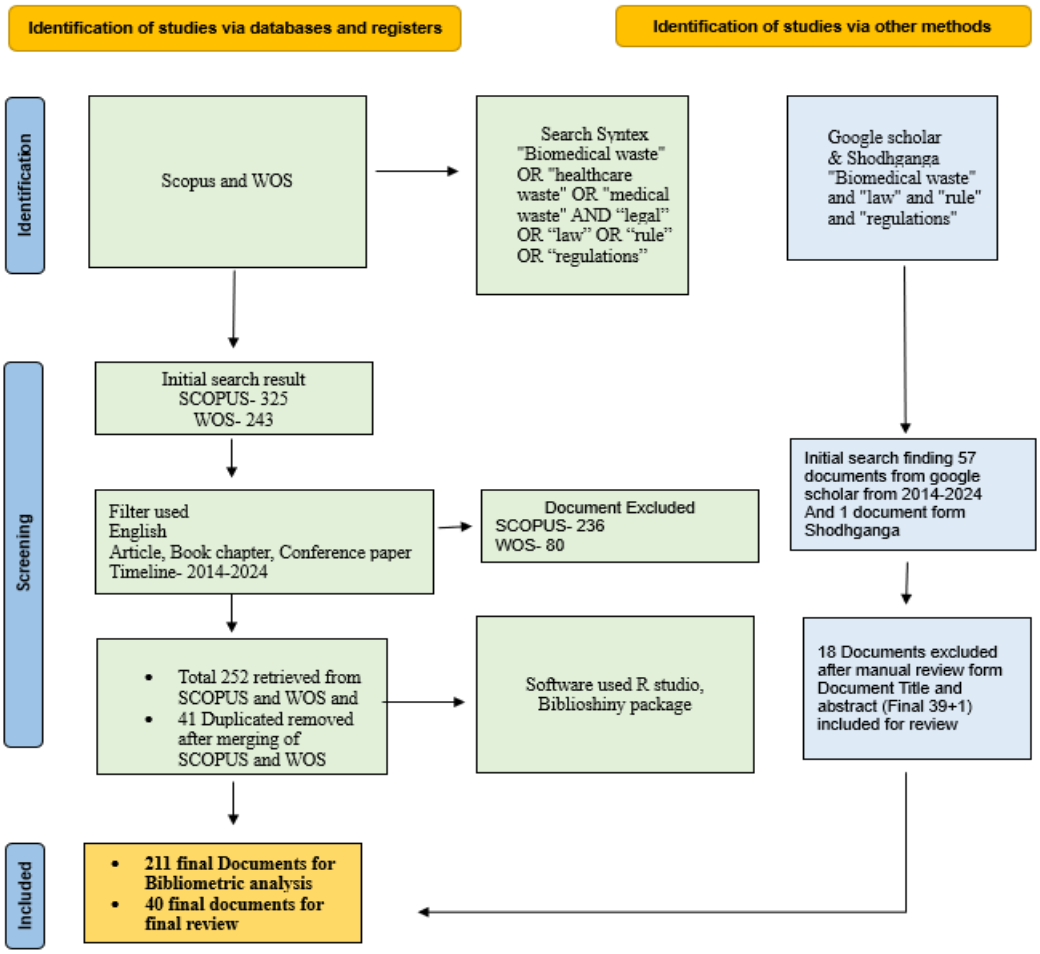
Identification of studies via databases and registers
Identification of studies via other methods
Identification
Scopus and WOS
Search Syntex "Biomedical waste" OR "healthcare waste" OR "medical waste" AND "legal" OR "law" OR "rule" OR "regulations"
Google scholar & Shodhganga "Biomedical waste" and "law" and "rule" and "regulations"
Screening
Initial search result SCOPUS- 325 WOS- 243
Filter used English Article, Book chapter, Conference paper Timeline- 2014-2024
Document Excluded SCOPUS- 236 WOS- 80
Initial search finding 57 documents from google scholar from 2014-2024 And 1 document form Shodhganga
Total 252 retrieved from SCOPUS and WOS and 41 Duplicated removed after merging of SCOPUS and WOS
Software used R studio, Biblioshiny package
18 Documents excluded after manual review form Document Title and abstract (Final 39+1) included for review
Included
211 final Documents for Bibliometric analysis
40 final documents for final review

Fig 3: Prisma for Literature

Overall findings of bibliometric analysis

The general details of data are shown in the (Table 1), where a total N=211 documents found from the 155source, and totally, here is observed 4.81% annual growth with average citation per year that is about11.46. The increasing tendency of the annual scientific production is presented in the fig 4 that shows higher value of documents produced in 2023.

Table: 2: Main information of the Data

Description	Results
"MAIN INFORMATION ABOUT DATA"	
"Timespan"	2014:2024
"Sources (Journals, Books, etc)"	155
"Documents"	211
"Annual Growth Rate %"	4.81
"Document Average Age"	5.32
"Average citations per doc"	11.46
"DOCUMENT CONTENTS"	
"Keywords Plus (ID)"	

“Author's Keywords (DE)”		663
AUTHORS		605
“Authors		
“Authors of single-authored docs”		822
“AUTHORS COLLABORATION”		16
Single-authored docs		
“Co-Authors per Doc”		16
“International co-authorships %”		4.16
“DOCUMENT TYPES”		15.64
“article”	154	
“article; book chapter”		2
“article; early access”		5
“book chapter”		5
“conference paper”		10
“proceedings paper”		14
“review”		21

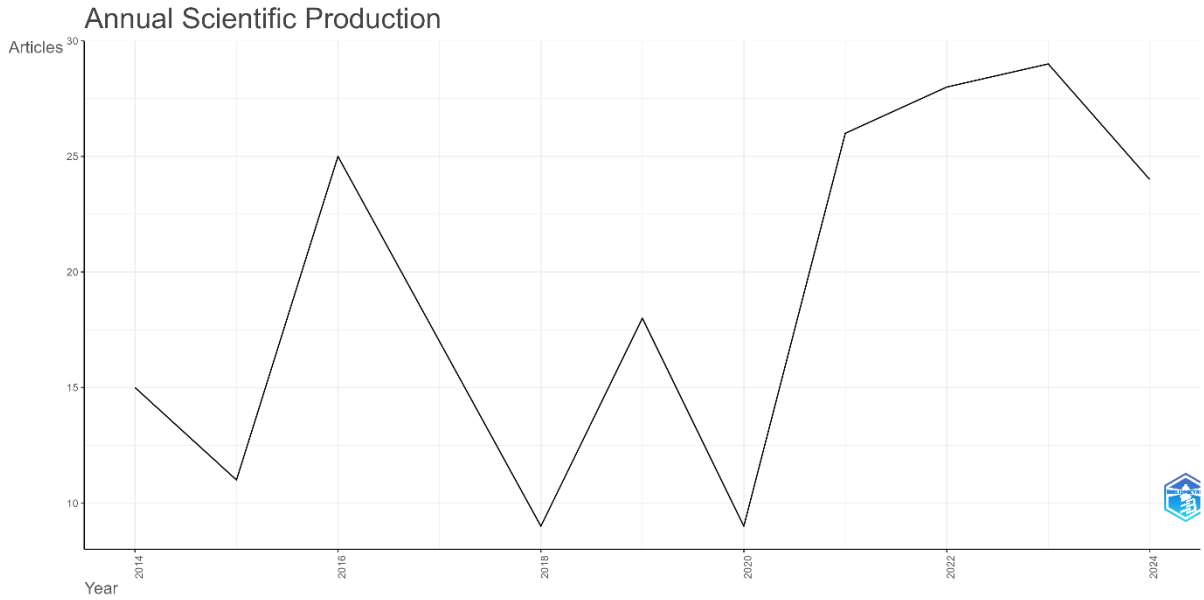

Fig 4: Annual scientific production

Trend Topics Analysis

The trend topics shown in the Fig.5 which provides an overview of the evolution of key themes in ‘bio-medical waste’ (BMW) research over time. The trend shows that words such as ‘medical waste’ management, hazardous waste, environmental regulations and disposal of waste have followed upward trends especially from 2019. Previous studies (2016–2018) were

mostly on waste generation, disposal processes and hospital waste, indicating that the early works were focused at knowing the extent of the problem in comparison to being compliant with regulations. The increase in word usage regarding sharing of knowledge, municipal solid waste and just 'waste management' between the years 2020- the end speaks to a developing consciousness and increased stringent enforcement or awareness concerning how trash has been disposed of. This implies a tendency from problem setting to solution-oriented measures. But the graph does not identify district level case studies regarding enforcement of BMW 2016 rules, in terms of compliance. Also, although awareness and knowledge sharing seem to be developing themes, there is limited evidence in the literature that investigates the real effect of training on BMW rule compliance. By identifying the key themes in the search results, we demonstrated that there was an increased interest in environmental regulations and health risks over time (based on the number of related publications) reflecting a concern for public health and sustainability; however, understanding the role of regional governance and hospital management to ensure compliance is poorly addressed. This gap creates an opportunity for your study to assess the operational level of BMW 2016 regulations implementation, their police adherence, segregations at source practices and compliance of healthcare facility at district-level in Nainital (Uttarakhand) state.

Thematic Map Analysis

The conceptual maps classify the investigation topics ofinto several dimensions: 'centrality' and 'density'. Motor themes happen to be highly developed and well researched subjects (top right quadrant), including law, legislation and "medical waste" disposal and hospital "waste management", as well as cross-sectional studies. This indicates well-explored roperty and hospital waste disposal patters at a high level. Yet the theme map also indicates fundamental themes (lower right quadrant) as an important yet underdeveloped area of research. Issues such as 'COVID-19', 'medical waste management' and, 'municipal solid waste' fall in this quadrant implying their topical importance to the field but also attention lacking particularly with respect to localized application. Biomass heavy metals water The upper left quadrant consists of topics such as biomass, heavy metals and water management that are highly developed but not focused intensively as the centre to regulate e.g. 'bio-medical waste'. This indicates that a few papers concentrate on the environmental impact of BMW, but these are not incorporated in the core research subjects: laws and compliance. A critical knowledge gap is found between the rising or falling themes (lower-left quadrant), and where organizational norms and risk management lay. The neglect of these three themes shows that 1) risk analysis and its various

strategies were understudied; 2) enforcement problem was less examined, and yet enforcement issue formed one of the core materials in BMW regulation but also causes conflict between the central instruction and local behavior (Hall 1983); and 3) institutional compliance with the regulations was relatively underdeveloped regarding BMW 2016, particularly at provincial level. This points at a critical void your study can fill by going after the reasons and obstacles of implementation in Nainital's healthcare services as well as an enforcement bottleneck.

Research Framework Map Analysis

The conceptual structure map organizes research themes based on their relationships and conceptual similarities. It indicates the top co-occurring terms occuring along with more than average frequency in 'bio-medical waste' literature. Much of the research has found its place in legislation, and also jurisprudence, government regulation as well as dangerous waste and 'medical waste' disposal, showing that most of the academic discussion has been focused on policy making issues and rules compliance. Finally, themes related to health infrastructure or public health and waste management seem to suggest an increasing imprimatur of hospitals and healthcare facilities in the management of 'bio-medical waste'. Yet on closer examination there has been relatively little research on the connection between policy and law enforcement at the street level. Though, the laws and regulations are in place but its implementation especially in small district is still virgin territory. The involvement of countries such as Iran, China and India on the map also indicates that most studies were performed in a national scope instead of district-level compliance. The cluster between incineration awareness, waste segregation and hospital waste suggests that although these factors are studied, their relationships with compliance with the BMW 2016 regulations remain limited. "In the case of Nainital district or such like areas, downloading such kind of papers from global net to find whether you have studied that material would be a waste of time as no special discussion is made in the thesis on Nainital district or similar areas but has discussed through primary data collection and results at different places. Through district-level analysis of BMW 2016 implementation, detection of hospital compliance gaps and consideration of the effect of regulatory enforcement, your research will make a significant contribution to this under-researched field.

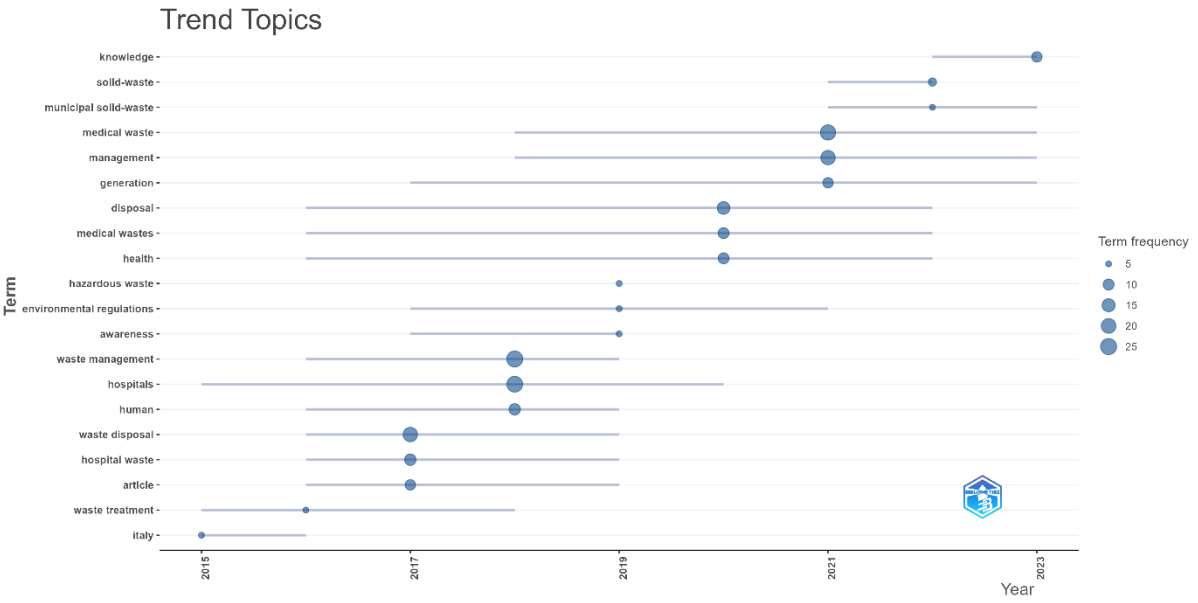

Fig.5: Trending topics

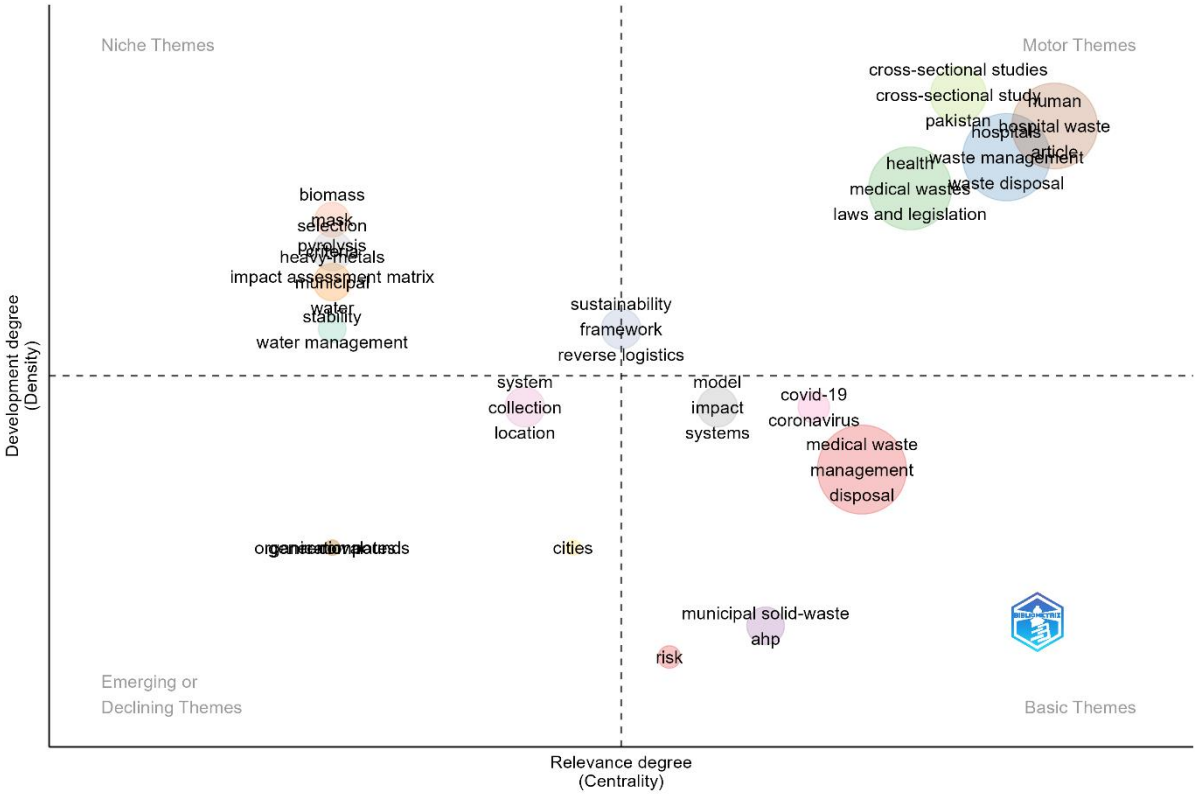

Fig.6: Thematic analysis

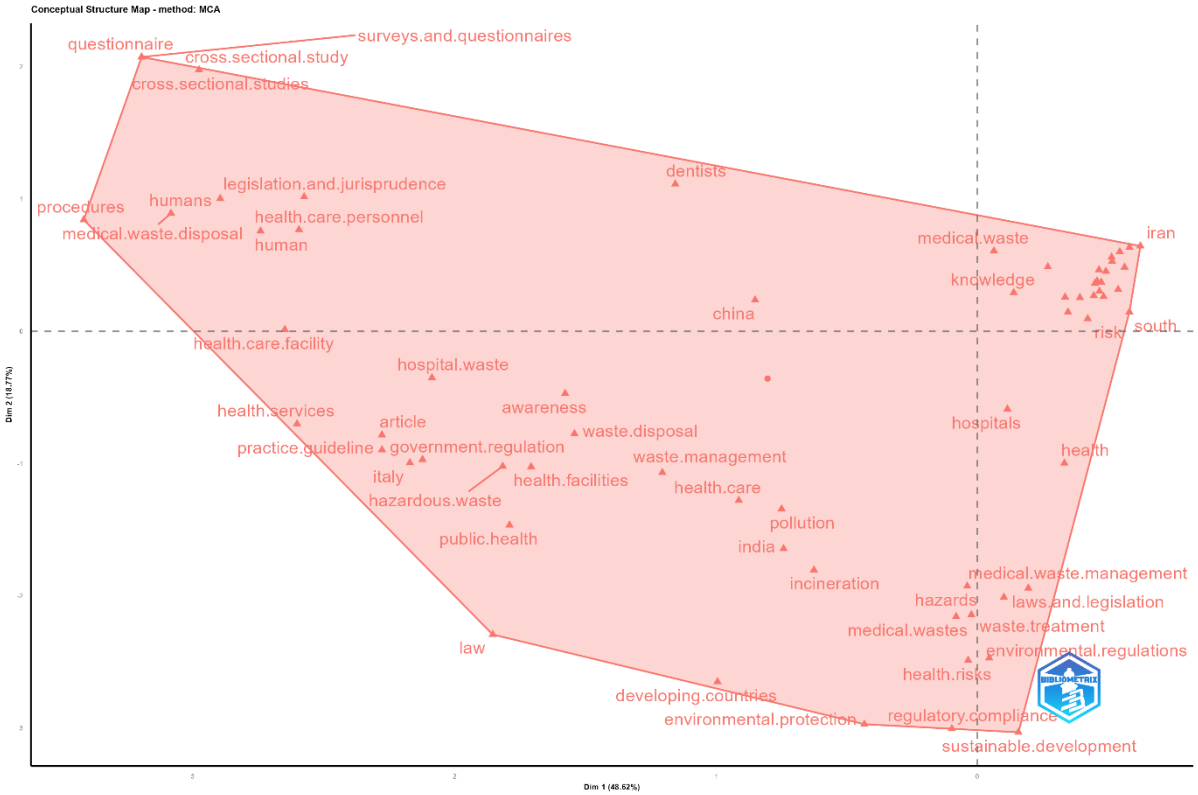

Fig 7: c

Phase II of Literature review

For the second phase of literature the through search of paper has been conducted using the google scholar and Shodhganga where, 57 results as shown in Fig.8 have been found in the google scholar form 2014-2024, and N=1 found in Shodhganga, for the final included document the manual review has been conduct and N=39 included from the google scholar and 1 included from Shodhganga. As shown in Fig.1. The detail analyses of the selected document are shown in Table 3

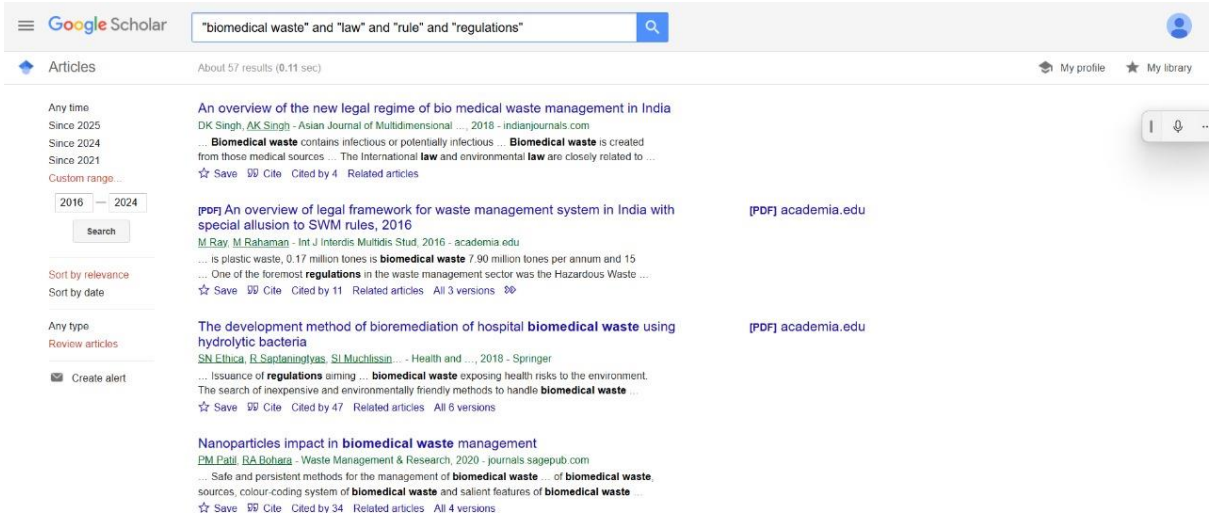
Google Scholar
"biomedical waste" and "law" and "rule" and "regulations"
Articles
About 57 results (0.11 sec)
My profile
My library
Any time
Since 2025
Since 2024
Since 2021
Custom range...
2016 — 2024
Search
Sort by relevance
Sort by date
Any type
Review articles
Create alert
An overview of the new legal regime of bio medical waste management in India
DK Singh, AK Singh - Asian Journal of Multidimensional ..., 2018 - indianjournals.com
... Biomedical waste contains infectious or potentially infectious ... Biomedical waste is created from those medical sources ... The International law and environmental law are closely related to ...
Save Cite Cited by 4 Related articles
[PDF] An overview of legal framework for waste management system in India with special allusion to SWM rules, 2016
[PDF] academia.edu
M Ray, M Rahaman - Int J Interdis Multidis Stud, 2016 - academia.edu
... is plastic waste, 0.17 million tones is biomedical waste 7.90 million tones per annum and 15 ... One of the foremost regulations in the waste management sector was the Hazardous Waste ...
Save Cite Cited by 11 Related articles All 3 versions
The development method of bioremediation of hospital biomedical waste using hydrolytic bacteria
[PDF] academia.edu
SN Ethica, R Saptaningtyas, SI Muchlissin... - Health and ..., 2018 - Springer
... Issuance of regulations aiming ... biomedical waste exposing health risks to the environment. The search of inexpensive and environmentally friendly methods to handle biomedical waste ...
Save Cite Cited by 47 Related articles All 6 versions
Nanoparticles impact in biomedical waste management
PM Patil, RA Bohara - Waste Management & Research, 2020 - journals.sagepub.com
... Safe and persistent methods for the management of biomedical waste ... of biomedical waste, sources, colour-coding system of biomedical waste and salient features of biomedical waste ...
Save Cite Cited by 34 Related articles All 4 versions

Fig.8 Search result from Google scholar

Table 3: Detail analyses of the selected Documents

Sl No	Author Year	Title	Journal name/Publisher	Methodology used	Conclusion/research gap
1	Achak et al., 2020	"SARS-CoV-2 in hospital wastewater during outbreak of COVID-19: A review on detection, survival and disinfection technologies"	'Science of the Total Environment'	Literature review	Lack of studies on long-term effects of virus presence in wastewater
2	Adams et al., 2008	"Essential Environmental Health	'Geneva'	Guidelines and	Limited focus on hospital-specific

		Standards in Health Care"		standards review	'waste management'
3	Agamuthu&Barasarathi, 2021	"Clinical waste management under COVID-19 scenario in Malaysia"	'Waste management & Research'	Case study analysis	Need for more data on waste production rates during pandemics
4	Ahmed et al., 2021	"Recent developments in physical, biological, chemical, and hybrid treatment techniques for removing emerging contaminants from wastewater"	'Journal of Hazardous Materials'	Experimental research and review	Gaps in understanding combined effects of different treatment methods
5	Akiba et al., 2015	"Impact of wastewater from different sources on the prevalence of antimicrobial-resistant	'Ecotoxicology and Environmental Safety'	Microbial analysis and statistical study	Lack of data on regional differences in antimicrobial resistance spread

		Escherichia coli in sewage treatment plants in South India"			
6	Akter et al., 2012	"Ciprofloxacin-resistant Escherichia coli in hospital wastewater of Bangladesh and prediction of its mechanism of resistance"	'World Journal of Microbiology and Biotechnology'	Microbial resistance analysis	Identified antibiotic resistance in hospital wastewater but lacks mitigation strategies.
7	Al Aukidy et al., 2018	"Hospital wastewater treatments adopted in Asia, Africa, and Australia"	'Handbook of Environmental Chemistry'	Comparative review of hospital wastewater treatments	Compared different treatment methods but lacks region-specific policy insights.
8	Al Qarni et al., 2016	"Investigating the removal of some pharmaceuti	'Environmental Science and	Pharmaceutical pollutant removal study	Studied pharmaceutical compound removal but does

		cal compounds in hospital wastewater treatment plants operating in Saudi Arabia"	Pollution Research'		not address alternative treatment methods.
9	Ali et al., 2016	"Synthesis of composite iron nano adsorbent and removal of ibuprofen drug residue from water"	'Journal of Molecular Liquids'	Adsorption technique for water purification	Developed a nano adsorbent but lacks large-scale application validation.
10	Allen et al., 2012	"Emission of airborne bacteria from a hospital incinerator"	'Journal of Air Pollution Control Association'	Airborne bacteria monitoring and emission study	Analyzed airborne bacteria emissions but lacks epidemiological impact studies.
11	Chowbe, 2011	"Legal Analysis of Rights Against the Protection of â€˜Bio-'medical waste'â€™	'SSRN Electronic Journal'	Legal analysis and judicial review	Addresses legal challenges but lacks empirical case studies on enforcement.

		and Judicial Reflections in India"			
12	Datta et al., 2018	"Bio-medical waste management in India: Critical appraisal"	'Journal of Laboratory Physicians'	Critical appraisal and case study	Critically examines 'bio-medical waste' management but needs more region-specific analysis.
13	Chisholm et al., 2021	"Sustainable 'waste management' of medical waste in African developing countries: A narrative review"	'Waste management & Research'	Narrative review	Explores sustainable 'medical waste' practices but lacks field validation in African countries.
14	Kumar et al., 2023	"Assessing Solid waste management Practices: A Gateway Towards Sustainable Development in Uttarakhand"	'Sustainable Development Research'	Field study and policy evaluation	Analyzes 'waste management' in Uttarakhand but lacks quantitative impact assessment.

15	Solanki, 2023	"Understanding Natural Resources Depletion in the Context of Uttarakhand and Concerns regarding waste management"	'Indian Journal of Law & Legal Research'	Legal and policy assessment	Highlights natural resource depletion but does not propose concrete 'waste management' solutions.
16	Ali et al., 2013	"Performance of sequencing anoxic/anaerobic membrane bioreactor (SAM) system in hospital wastewater treatment and reuse"	'European Scientific Journal'	Experimental research on wastewater treatment	Evaluates membrane bioreactor performance but lacks cost-effectiveness assessment.
17	Allen et al., 2012	"Emission of airborne bacteria from a hospital incinerator"	'Journal of Air Pollution Control Association'	Airborne bacteria monitoring	Analyzes airborne bacterial emissions but lacks impact

					correlation with public health.
18	Amarasiri et al., 2020	"Understanding human health risks caused by antibiotic-resistant bacteria (ARB) and antibiotic resistance genes (ARG) in water environments"	'Critical Reviews in Environmental Science and Technology'	Literature review on antibiotic-resistant bacteria in water environments	Reviews antibiotic resistance in water but lacks empirical data on transmission patterns.
19	Amoah et al., 2022	"Effect of selected wastewater characteristics on estimation of SARS-CoV-2 viral load in wastewater"	'Environmental Research'	Experimental study on SARS-CoV-2 viral load in wastewater	Assesses wastewater characteristics for SARS-CoV-2 detection but needs broader epidemiological validation.
20	Amouei et al., 2015	"Characteristics of effluent wastewater in hospitals	'Health Scope'	Hospital effluent analysis and assessment	Studies hospital wastewater effluents but lacks comparative

		of Babol University of Medical Sciences, Babol, Iran"			analysis across different regions.
21	Ansari et al., 2019	"Dynamic assessment of economic and environmental performance index and generation, composition, environmental and human health risks of hospital solid waste in developing countries"	'Environmental International'	Environmental and economic risk assessment	Provides a dynamic environmental risk assessment but needs long-term monitoring data.
22	Arslan et al., 2014	"Use of response surface methodology for pretreatment of hospital wastewater by O3/UV and	'Separation and Purification Technology'	Response surface methodology for wastewater pretreatment	Examines pretreatment methods but lacks real-world implementation studies.

		O3/UV/H2O 2 processes"			
23	Arub et al., 2020	"Assessment of waste generation rate in teaching hospitals of metropolitan city of Pakistan"	'Civil Engineering Journal'	Hospital waste generation assessment and data collection	Quantifies hospital waste but does not propose optimized disposal strategies.
24	Pant, S.	"Generation and Management of Municipal Solid Waste in Uttarakhand: A Geographica l Insight"	'Geographic al Research on 'waste management '	Geographica l analysis of 'waste management '	Analyzes municipal solid 'waste management' but lacks integration with policy effectiveness.
25	Khan et al., 2024	"A district-level vulnerability assessment of next COVID-19 variant (Omicron BA. 2) in Uttarakhand	'Environmen t, Developmen t and Sustainabilit y'	Quantitative SWOT analysis	Examines vulnerability to Omicron variant but needs long-term public health data.

		using quantitative SWOT analysis"			
26	Baruah et al., 2021	"Physiographic dispersal of Dengue in Uttarakhand, India"	'Dengue Bulletin'	Epidemiological and physiographic study	Studies dengue dispersal but lacks correlation with climate change patterns.
27	Parida et al., 2022	"An assessment of hospital wastewater and bio-medical waste generation, existing legislations, risk assessment, treatment processes, and scenario during COVID-19"	'Journal of Environmental Management'	Legislative analysis, risk assessment, and case study	Analyzes 'bio-medical waste' treatment but lacks post-COVID-19 policy adaptations.
28	Datta et al., 2018	"Bio-medical waste management in India:	'Journal of Laboratory Physicians'	Critical appraisal and case study	Critically examines 'bio-medical waste' management but needs more

		Critical appraisal"			region-specific analysis.
29	Chisholm et al., 2021	"Sustainable waste management of 'medical waste' in African developing countries: A narrative review"	"Waste management & Research"	Narrative review	Explores sustainable 'medical waste' practices but lacks field validation in African countries.
30	Author Year	Title	'Journal name/Publisher'	Methodology used	Conclusion/research gap
31	Singh, A., & Singh, S.	"A chapter of bio-medical waste in Uttarakhand"	'Indian Journal of Law and Legal Research, 4(4), 1'	Not specified	Research gap in localized 'bio-medical waste' management
32	Ahluwalia, I. J., & Patel, U.	"Solid waste management' in India: An assessment of resource recovery and environmental impact"	'Econstor, 1â€"49'	Not specified	Lack of regional case studies

33	Goli, V. S. N. S., Singh, D. N., & Baser, T.	"A critical review on thermal treatment technologies of combustible fractions from mechanical biological treatment plants"	'Journal of Environmental Chemical Engineering, 9(4), 105643'	Review-based analysis	Limited experimental validation
34	Joshi, A., & Joshi, N.	"Sanitation Park Nathuwawala, Dehradun: A study of solid waste management in Uttarakhand"	'Current World Environment, 15(1), 87â€"99'	Case study	Focuses only on one site
35	Recykal	"Transforming 'waste management' in Uttarakhand: The Char Dham	'Online blog'	Descriptive	No quantitative analysis

		success story"			
36	Tewari, G., Bhatt, D., Junne, S., Mundhe, R., Parale, S., & Baig, M. M. V.	"Municipal solid 'waste management' in Nainital, Uttarakhand: A case study"	'Quest - The Journal of UGC-ASC Nainital, 7(3), 288'	Case study	Limited comparative studies
37	Dumka, A., &Khanduri, P.	"KAP study on bio-'medical waste' management among nursing professionals in Haldwani (Nainital)"	'International Journal of Advanced Scientific Research and Management, 3(8), 141-148'	Survey-based study	Limited sample size
38	Sharma, N.	"Biowaste disposal: Uttarakhand pollution board seeks list of private hospitals"	'Hindustan Times'	News report	Lacks scientific methodology
39	Feedback Foundation	"Integrated decentralized solid waste management model at	'Online publication'	Descriptive	No empirical data

		Nathuwawala, Ward 100, Dehradun"			
40	National Green Tribunal (NGT)	"Ensure proper disposal of bio-'medical waste', NGT tells Uttarakhand hospitals"	'The Hindu'	Policy directive	Lack of impact assessment

4. Research Gap

Despite the existence of a strong legal framework, including the "Bio-medical waste Management Rules 2016", there remains a significant gap in the local implementation and enforcement of 'bio-medical waste' management in Dehradun. While national and international studies have addressed 'bio-medical waste' disposal challenges, district-specific empirical research focusing on hospital compliance, regulatory enforcement, and environmental impacts is lacking.

Some of the major gaps identified in this study are –

- Lack of empirical evidence on storage, segregation, disposal, and transportation of biowaste in Dehradun, while complying with regulatory commands.
- Lack of studies on effects of biomedical waste on the environment, especially in eco-sensitive cities like Dehradun.
- Lack of research on capacity-building, awareness, and role of unorganized waste handlers and healthcare staff in managing governance related to bio-medical waste.

This study will fill these gaps with regional investigation of managing bio-medical waste in Dehradun, based on established challenges, policy implementation and environmental sustainability for governing enforcements with data-based approach.

5. Research Objective

1. To investigate effective adoption of managing bio-waste in Dehradun

- This study investigates how healthcare facilities in Dehradun implement biomedical waste management as per the "Bio-medical waste Management Rules 2016"

2. To determine the role played by judicial bodies to promote "waste management" practices

- This study will investigate regulatory models and court verdicts which have impacted governance of "biomedical waste" in India
- It will also determine the effect of jurisdictional directions on regulatory application and compliance in healthcare units.

3. To analyze the effects of poor waste management on public health and environment as a whole.

- To find out how poor biomedical waste discarding cause high level of environmental damage in Dehradun.
- Identify health risks posed to residents due to exposure to biohazardous waste and contamination.

4. To determine challenges that healthcare units face when it comes to adhere to regulations made on waste management

- Investigate compliance levels among hospitals and barriers to effective waste disposal.
- Examine capacity-building initiatives, training programs, and awareness strategies for healthcare workers.

5. To Propose Policy Reforms and Sustainable Solutions for Improved 'bio-medical waste' Governance.

a. Recommend technological advancements, such as digital tracking systems, for waste monitoring.
b. Advocate for eco-friendly disposal practices and waste-to-energy conversion models to promote sustainability.

6. Research Hypothesis

1. Bio ‘medical waste’ management in Dehradun suffers from inconsistent implementation despite strong legal framework.

2. Judicial Intervention have significantly contributed in strengthening and implementing ‘bio medical waste’ management rules in India.

3. Substandard ‘Bio medical waste’ management protocols in Dehradun have generated immense ecological damage and increased the health risks for residents.

7. Research Questions

1. How effective is the implementation of ‘bio-medical waste’ management regulations in Dehradun despite the existence of the ‘Bio-medical Waste’ Management Rules, 2016?
2. What role has judicial intervention played in strengthening ‘bio-medical waste’ management enforcement and compliance in India?
3. What are the primary challenges hospitals in Dehradun face in ensuring proper waste segregation, disposal, and adherence to regulatory standards?
4. What are the environmental and public health risks associated with substandard ‘bio-medical waste’ management protocols in Dehradun?
5. How can policy reforms, technological advancements, and sustainable waste disposal mechanisms improve ‘bio-medical waste’ governance in Dehradun?

8. Research Methodology

This methodology is based on integrating both empirical and regulatory analysis to provide in-depth knowledge of compliance in hospitals, regulatory challenges, and environmental effect. This study is also based on doctrinal or secondary data, which covers judicial verdict related to “National Green Tribunal (NGT)”, “Biomedical Waste Management Rules, 2016”, and reports released by the “State Pollution Control Board.” Additionally, public databases and academic journals were referred for some key understandings like “Shodhganga”, “Web of Science”, and “Google Scholar”. Standard for governance and “biomedical waste” management has been set over best practices in legal research.

This study was also based on primary data collected through field surveys, interviews, and studies conducted in hospitals and biowaste plants in Dehradun. A survey was conducted on 100 participants, including doctors, nurses, and waste handlers to determine waste disposal, compliance, and challenges related to healthcare institutions. For qualitative data, interviews were held with municipal, government, and environmental institutions when it comes to address infrastructural gaps. Data collected were analyzed with quantitative and qualitative research tools like IBM SPSS and MS Excel spreadsheet to identify compliance trends and waste generation levels.

In addition, policy gaps and challenges related to governance were tracked with thematic analysis, which was conducted on discussions related to focus groups and interviews. Findings of the study fill the gap by offering data-based knowledge about bio waste management, while focusing on policy gaps, environmental risks, and policy recommendations in Dehradun.

8.1 Research Design

Research has been planned to be doctrinal and empirical:

Doctrinal Research

Analysis of secondary data sources like legal documents, government reports, court decisions, policy papers, and academic articles will form the base of the study. This approach will be helpful to perform critical analysis on environmental law with comparative law research.

Empirical Data Collection

Along with doctrinal research, empirical data was collected through observational research, interviews, and field surveys from pathology labs, veterinary care centers, NGOs, hospitals, and other healthcare units. Empirical data was collected to analyze compliance levels, practices related to waste disposal, and assessing effects on environment in selected locations.

8.2 The scope of institutions

In order to have a thorough study on the practice of bio-medical waste management, the sample will be extended to encompass more health and allied institutions. These will include government and non-government hospitals, pathology/diagnostic laboratories, veterinary hospitals and clinics and Non-Governmental Organizations/community-based organizations dealing with bio-medical waste management, awareness or disposal of bio-medical waste. The

incorporation of such a wide range of institutions will allow evaluating the states of bio-medical waste management in various institutions and among various stakeholders.

8.3 Survey Location

Focusing exclusively on Dehradun city enhances the study's relevance, as it has the highest concentration of hospitals and generates the largest volume of 'bio-medical waste' in Uttarakhand. As the state capital, Dehradun houses government hospitals, private clinics, research institutions, and 'bio-medical waste' treatment facilities, making it a critical site for evaluating compliance with the "Biomedical waste Management Rules 2016", and identifying regulatory enforcement challenges.

Sample collection and Study Area

It would be a research done in the Dehradun Municipal Corporation (DMC) limits comprising of the urban and semi-urban areas. The facilities to be considered in the list should be within the DMC area and involved actively in the generation or management of bio-medical waste.

Mechanism of data collection

The collection of data is going to be conducted in terms of a combination of methods:

Structured Questionnaires by hospital administrators/laboratory personnel veterinary doctors, sanitation workers, as well as NGO representatives.

Observe Checklists as per the Bio-Medical Waste Management Rules, 2016 to record material segregation on site, use of color-coded bins, storage, transport, and disposal.

Reviews of registers, manifests and record of healthcare facilities and Common Bio-medical Waste Treatment Facilities (CBWTFs).

The interviews with the regulatory officials and NGO representatives are conducted to gain access to the perceptions of compliance, enforcement, and awareness challenges.

In order to validate observations using photographs and fieldnotes (where granted), all facilities will be geo-tagged. Quality control will also be ensured by inspections made by the supervisor daily and by back-checks.

8.4 Sample, Sampling Size, and Sampling Technique

Statistical validity and embodiment have been ensured by calculating sample size. Minimum 267 participants were calculated to be required as per "Cochran's formula" with 6% of margin of error and 95% confidence interval. Hence, around 320 respondents were targeted, considering odds for non-response and stratification with calculated final sample size of minimum 300 responses.

There are three stages of performing "multi-stage sampling" method –

- Stage 1 – This step involves stratification of institutions into NGOs, veterinary care units, diagnostic/pathology labs, hospitals, regulatory institutions, and CBWTFs.
- Stage 2 - Facilities are selected in each level to capture urban/semi urban, large/small, and private/government bodies
- Stage 3 – Participants are selected systematically in each facility from major roles like veterinary/lab staff, CBWTF operators, sanitation staff, clinical staff, administrators, and field workers in NGOs.

The research design and revised sample size are expected to reduce bias, promote generalizability, and improve accuracy of findings.

8.5 Research Tools

Here are the following doctrinal and empirical research tools used to conduct the study successfully -

Doctrinal Research Tools:

This study consists of review of government reports, reviewing bodies, judicial models, and policy documents. For BMW laws in India, global best practices are benchmarked with comparative studies.

Empirical Research Tools:

For empirical data collection, a self-structured questionnaire was prepared and shared among hospital staff, waste handlers, and management staff to know their compliance levels, understanding, and practices.

In addition, "Focus Group Discussions" and interviews were organized with environmental, medical, and regulatory bodies to know policy gaps and challenges related to governance at

grass root level. Finally, field trials were conducted to assess waste collection, segregation, and disposal in hospitals.

Data Analysis Software:

When it comes to data analysis, Excel spreadsheet and IBM SPSS tools were used for analyzing quantitative data to analyze patterns and trends related to waste generation and compliance. In addition, quantitative data collected through focus group discussions and interviews was interpreted through thematic analysis. Combining these statistical tools, case studies, and legal analysis ensure relevance and comprehensiveness of research findings.

9. Expected Outcome of the research work

A thrust to provide a comprehensive view of the 'bio-medical waste' (BMW) disposal system in Dehradun city with regard to regulatory enforcement, environmental consequences, and eco-friendly waste disposal solutions is the research on Legal and Environmental Governance of 'Bio-medical waste': An Empirical Case Study of Dehradun. The study may provide valuable knowledge about both efficiency of existing legal bodies and environmental effects of biomedical waste.

1. Improved Policy and Legal Framework

When it comes to actual adoption of "BMW Management Rules, 2016", the study investigates ground-level formulation and find gaps in policy development. Following are some of the outcomes expected in this study -

- There is regulatory gap in the present governance system, such as, insufficient regulatory control and lack of strict penalties for non-performance
- Improper collaboration leads to lack of enforcement among regulatory, local, and healthcare bodies.

2. Enhanced BMW systems

Especially for dissemination, collection, transportation, and disposal of waste, some major flaws will be revealed in this study in the current segregation of biomedical waste. Improper waste management results in public health concerns and increased risks of contamination in hospitals.

3. Assessing effects on environment and public health

Overall quality of air, water, and land is affected by BMW without proper removal. Hence, worst effect of this condition is investigated in this study, especially in context of Dehradun. For example, unmanaged burning of bio-waste leads to air pollution, unmanaged disposal of hospital waste into groundwater and rivers lead to water pollution, and these practices increase waterborne illnesses and antibiotic-resistant germs.

4. Adopting Technology and Sustainable Solutions

One of the best outcomes of this study expected would be evaluating sustainable practices and innovative technologies for waste management to manage biological waste.

5. Enhanced capacity building and sensibility

Another major research contribution is defining training and knowledge gaps among waste controllers, common public, and hospital staff on proper disposal of bio-medical waste –

- There is a lack of knowledge about approaches to manage bio-waste among healthcare staff.
- There is a lack of suitable safety protocols and protective gear for waste handlers, making them vulnerable to biohazards and infections

Roadmap for future improvements and policy suggestions

This study will deliver a strategic roadmap for healthcare units, regulatory authorities, and lawmakers to improve the practices to manage biological waste in Dehradun. Putting more "Common Biomedical Waste Treatment Facilities (CBWTFs)" in isolated places can lead to an upgradation of treatment capacity for the wastes thus allowing for appropriate disposal of 'bio-medical wastes.'

Integrated plans for BMW should be formulated to promote sustainability goals and international best practices. For promoting BMW control funding, technology uptake, and infrastructure, PPPs should be adopted. Finally, environmental and regulatory governance of BMW will provide needed insights about policy deficiencies and challenges of waste management. By analyzing waste disposal, legal clauses, and measures related to technology, the study provides important insights to promote governance related to BMW.

10. Proposed Chapterisation

Chapter 1: Introduction

This chapter covers fundamentals of BMW handling, focusing on its importance, public health and environmental issues, and regulatory model. It sets the foundation for research objectives, gaps, and hypotheses.

Chapter 2: BMW and Human Health and Environment – Historical Evolution and Theoretical Framework

This chapter is based on the practices related to biomedical waste control in the past, tracing its effect on public health and environment. It discusses hazards, key concepts, challenges related to disposal, and classification of biomedical waste.

Chapter 3: National/Global Levels of BMW Management

This chapter focuses on analysis of regulatory frameworks in Indian and global context. It also performs comparison of governance models related to biomedical waste management in different regions. It focuses on institutional issues and policy gaps which may affect proper BMW handling.

Chapter 4: Judicial Enunciation – BMW Management and Sustainability

This chapter evaluates judicial verdict, landmark judgments, and legal examples redefining governance related to BMW management. It determines judiciary's role in promoting sustainability and policy enforcement.

Chapter 5: An Empirical Survey on BMW Management in Dehradun hospitals

This chapter presents valuations related to compliance in hospitals, field data, and challenges related to regulatory implementation in Dehradun. It analyses possible policy interferences, recognized lapses, and trends related to waste disposal.

Chapter 6: Conclusion and Recommendations

This chapter concludes key findings of the study, such as, novel technologies, reforms, and strategies for improved governance of BMW. It provides suggestions for making the world a better place with proper BMW management. It will provide a clear picture to the readers about compliance with operational, legal, and environmental norms in Dehradun and Nainital.

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11. Month wise Plan of the Work

TASK	MONTH WISE PLAN IN QUARTERS FROM 2025 TO 2026							
	YEAR 2025 (in 4 Quarters)				YEAR 2026 (in 4 Quarters)			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
[1] Thesis Proposal Approved								
[2] Extended Literature Review								
[3] Identify Stakeholder and Collect Empirical Data								
[4] Chapter 1 and 2.								
[5] Chapter 3 and 4.								
[6] Chapter 5 To 7.								
[7] Pre Ph.D. Seminar								
[8] Publications								
[9] Thesis Submission								